



## SHORT NOTE

### First Record of Gynandromorphism in *Augochlora phoemonoe* and an Updated List of Gynandromorphs in Halictinae

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#### Article History

##### Edited by

Felipe Vivallo, UFRJ-Museu Nacional, Brazil

Received	04 September 2025
Initial acceptance	06 November 2025
Final acceptance	13 November 2025
Publication date	30 March 2026

##### Keywords

Gynandromorph, Halictidae, Hymenoptera, Mosaic, deviant phenotypes.

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#### Abstract

We report here a new case of gynandromorphism in *Augochlora phoemonoe*, collected in Morro Redondo, Rio Grande do Sul. The specimen exhibits a combination of male and female morphological characters distributed asymmetrically across the head and mesosoma, the metasoma is entirely male, classifying it as a mixed-type or mosaic gynandromorph. This is among the few records of this condition in the tribe Augochlorini, contributing to the understanding of morphological diversity and the occurrence of sexual anomalies in Halictinae. Currently, 27 cases of gynandromorphism are known for the subfamily, with most of them being mosaic type.

Gynandromorphs are individuals exhibiting morphological characteristics of both sexes. In bees, this condition is of particular interest as it provides opportunities for comparative analyses of sexual traits and for identifying diagnostic structures (Hinojosa-Díaz et al., 2012). Gynandromorphs can be classified as bilateral, transverse, or mosaic, according to the distribution of sexual characters (Dalla Torre & Friese, 1899). The tribe Augochlorini is exclusive to the Americas, with its highest diversity in tropical regions. Within this tribe, the genus *Augochlora* stands out for its wide distribution, from southern Canada to Argentina, and for being among the most species-rich (Dalmazzo & Roig-Alsina, 2011). *Augochlora phoemonoe* (Schrottky, 1909) occurs in southern South America: Argentina, Brazil, Paraguay, and Uruguay (Lepeco & Gonçalves, 2020). The nests are excavated in decaying wood, with cells built from chewed, decaying wood

particles, clustered tightly and supported by pillars within a surrounding cavity, and following a cycle typical of temperate-zone halictines (Dalmazzo & Roig-Alsina, 2018). The social behavior of *A. phoemonoe* is characterized by a eusocial structure with a clear division of labor. Colonies begin as solitary nests and transition into an eusocial structure with at least two broods, with daughters remaining in the nest as non-reproductive subordinates. Colony integration is maintained through frequent social interactions, and colonies typically remain small, consisting of 1-3 first-brood females during the summer foraging period (Dalmazzo & Roig-Alsina, 2015). The present work reports a new case of gynandromorphism in *Augochlora phoemonoe* and provides an updated list of known halictine gynandromorphs.

The gynandromorph of *Augochlora phoemonoe* was collected by a blue pan trap. The collection site is an organic



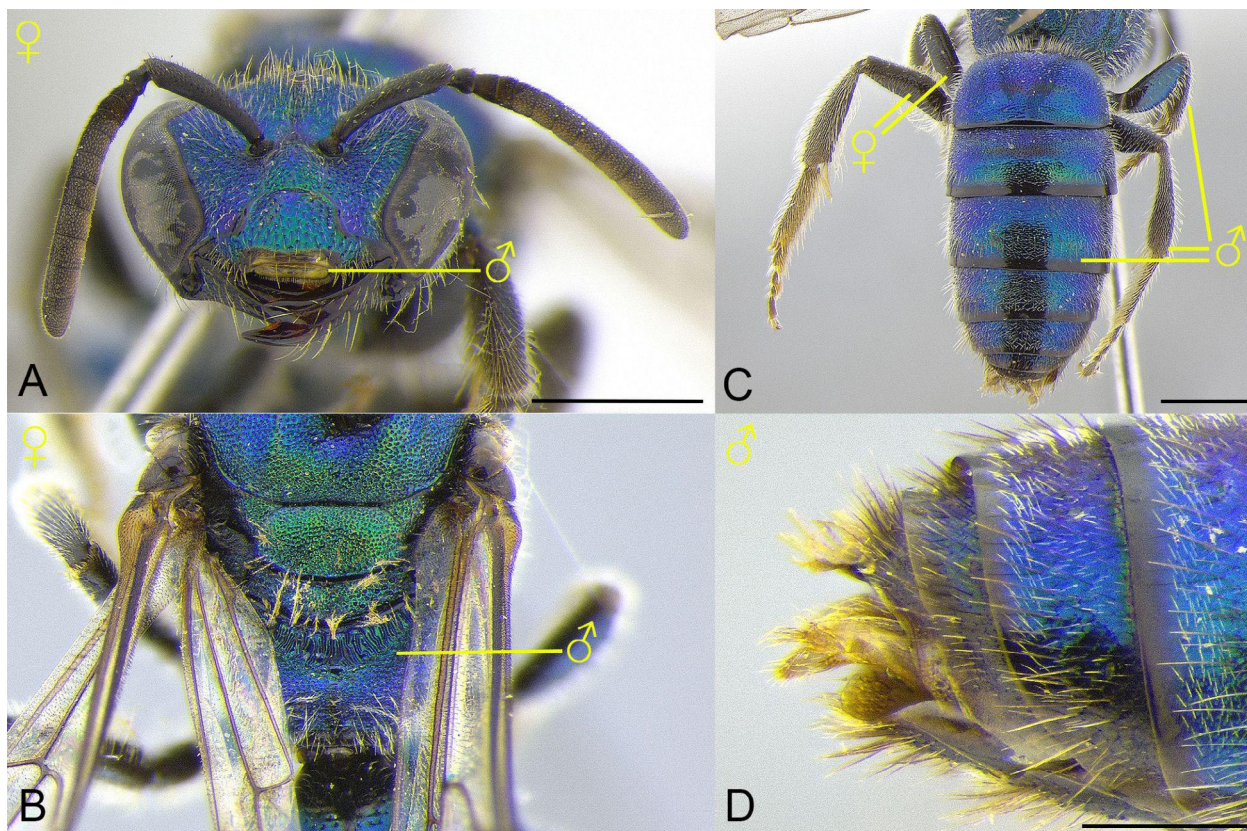
farming area in Morro Redondo, in southern Brazil, in the state of Rio Grande do Sul. The original label data is “Brasil, RS, Morro Redondo\ Propriedade 3 Orgânica\ Cultivo\ 31°31 42.02S, 52°37 22.06W\ 23.XII.2022\ Kurz, M.”. We also examined conspecific females and males deposited in the Departamento de Zoologia, Universidade Federal do Paraná. External morphological structures were studied using an Olympus SZ61 and Leica M125C stereomicroscope and photographed with Flexacam c5. We follow the terminology and species circumscription proposed by Dalmazzo & Roig-Alsina (2011) and Lepeco & Gonçalves (2020). As both sexes were recently described in detail in two taxonomic accounts, we only provide notes comparing female and male attributes.

The *A. phoemonee* gynandromorph. **Head:** largely female-like in general shape, as long as wide (male has elongate head) and with sparse branched setae (abundant long branched setae on male), antennae have 10 flagellomeres, and mandibles have preapical tooth; however, the clypeal apex has a yellow lateral marks and lacks long setae (black and with long setae on females) the labrum is yellow and lacks the apical elevation and developed keel (present on females) (Fig 1A, as Dalmazzo & Roig-Alsina 2011: Fig 22). **Mesosoma:** mixed, prothorax, mesothorax and metathorax female-like in shape and sculpture; on the other hand the metapostnotum is deeply striate as the male and propodeum has coarse punctures (finer on females) (Fig 1B). Forelegs and left midleg female-like, including the species diagnostic swollen trochanter;

the right midleg is male-like. Left hind leg with long, dense pilosity consistent with a well-developed female scopa and inner tibial spur with enlarged base; right hind leg with shorter, sparser pilosity and with fine inner tibial spur, as in males (Fig 1C). **Metasoma:** entirely male-like, S1 without spine, only with raised median line and with seven visible terga and male genital structures (gonostylus and gonapophysis) evident at the apex of the abdomen (Fig 1C-D).

The specimen exhibits morphological characters attributable to both sexes, with asymmetries distributed across the head, mesosoma, and metasoma, comprising distinct combinations of male and female structures and indicating mosaic gynandromorphism. Nothing is known about the behaviour of the gynander, as it was caught in a passive trap. However, we can speculate that the individual was unable to start a new nest due to the male metasoma, without a pygidial plate and pseudopygidial area, which are used in nest and cell construction (Batra, 1964).

Currently, 27 cases of gynandromorphism are known in halictine bees (Table 1), with most records coming from Halictini and Sphecodini. The most common type of gynandromorph is mosaic, with 20 cases documented. The number of records has increased since Wcislo et al. (2004), who reported 11 species, and Hinojosa-Díaz et al. (2012), who reported 21 species. A higher number of cases is expected given the high diversity and abundance of halictine bees. At that time, no records were known for Augochlorini.



**Fig 1.** Gynandromorph of *Augochlora phoemonee*. A, head in frontal view; B, mesosoma in dorsal view; C, metassoma in dorsal view; D, genitalia in lateral view. Scale bars: A–C 1.0 mm; D 0.5 mm.

The first record of a gynandromorph in Augochlorini (Halictinae) was published by Engel & Hinojosa-Díaz (2011), based on a specimen of *Thectochlora alaris* (Vachal). Additionally, two records are known for *Megalopta* and two for *Augochlora*.

The gynander of *A. daphnis* is classified as mosaic, but has extensive regions of head and mesosoma, and the T1 indicative of bilateral type (Alvarez et al., 2014), while the *A. phoemonoe* specimen studied here has less indication of bilateral type, only expressed on the hind legs. Regarding other augochlorine cases, *Thectochlora alaris* gynander presents indication of bilateral type on the head and legs, but mosaic in

remaining body (Engel & Hinojosa-Díaz, 2011). *Megalopta genalis* has mosaic type with head bilateral and mesosoma and metasoma as a typical female (Wcislo et al., 2010). The case more alike bilateral type is *Megalopta amoena* with head, mesosoma and sterna bilateral, but with terga shape similar to a female (Krichilsky et al., 2020). As for bees as a whole, there is no a clear pattern of gynandromorphism.

There are three main developmental causes of gynandromorphism. First, gynandromorphs may result from binucleate eggs (2n) in which one nucleus is fertilized, leading to the development of an individual with both male

**Table 1.** Known cases of gynandromorphism in Halictinae, organized by species.

Species	Type of gynandromorphism	References
<b>Augochlorini</b>		
<i>Augochlora (Augochlora) daphnis</i> Smith, 1853	Mosaic	Alvarez et al. (2014)
<i>Augochlora (Augochlora) phoemonoe</i> (Schrottky, 1909)	Mosaic	this study
<i>Megalopta amoena</i> (Spinola, 1853)	Bilateral	Krichilsky et al. (2020)
<i>Megalopta genalis</i> Meade-Waldo, 1916	Mosaic	Wcislo et al. (2004)
<i>Thectochlora alaris</i> (Vachal, 1904)	Mosaic	Engel & Hinojosa-Díaz (2011)
<b>Halictini</b>		
<i>Halictus quadricinctus</i> (Fabricius, 1776)	Mosaic	Saunders (1901)
<i>Halictus scabiosae</i> (Rossi, 1790)	Mosaic	Praz et al. (2024)
<i>Halictus sexcinctus</i> (Fabricius, 1775)	Mosaic	Leclercq (1953)
<i>Halictus simplex</i> group	Mosaic	Brau et al. (2024)
<i>Halictus tumulorum</i> (Linnaeus, 1758)	Mosaic, Transverse, Mosaic	Andrewes (1946); Hohndorf (1931); Wolf (1995a)
<i>Lasioglossum albipes</i> (Fabricius, 1781)	Mosaic	Nilsson (1987)
<i>Lasioglossum calceatum</i> (Scopoli, 1773)	Bilateral, Mosaic	Plateaux-Quénu (1982); Wolf (1990b)
<i>Lasioglossum eurygnathus</i> Blüthgen, 1931	Mosaic	Popov (1937)
<i>Lasioglossum fulvicorne</i> (Kirby, 1802)	Transverse	Wolf (1987a)
<i>Lasioglossum lativentre</i> (Schenck, 1853)	Transverse	Stöckhert (1924)
<i>Lasioglossum lissonotum</i> (Noskiewicz, 1925)	Transverse	Wolf (1990)
<i>Lasioglossum malachurum</i> (Kirby, 1802)	Mosaic	Stöckhert (1924)
<i>Lasioglossum morio</i> (Fabricius, 1793)	Bilateral, Mosaic, Mosaic, Mosaic	Arp (2020); Wolf (1986); Wolf (1997b) (2 specimens)
<i>Lasioglossum pauxillum</i> (Schenck, 1853)	Mosaic	Wolf (2003a)
<b>Nomioidini</b>		
<i>Nomioides minutissimus</i> (Rossi, 1790)	Mosaic	Wolf (1997a)
<b>Sphecodini</b>		
<i>Sphecodes albilabris</i> (Fabricius, 1793)	Mosaic	Wolf (1994)
<i>Sphecodes geoffrellus</i> (Kirby, 1802)	Mosaic	Wolf (1987b)
<i>Sphecodes gibbus</i> (Linnaeus, 1758)	Mosaic	Wolf (2003b)
<i>Sphecodes niger</i> Hagens, 1874	Transverse	Wolf (1991)
<i>Sphecodes pellucidus</i> Smith, 1845	Mosaic	Wolf (1997b)
<i>Sphecodes reticulatus</i> Thomson, 1870	Bilateral	Stöckhert (1924)
<i>Sphecodes rufiventris</i> (Panzer, 1798)	Mosaic	Wolf (1987b)

(n) and female (2n) tissues (Narita et al., 2010; Michez et al., 2012). Second, polyspermy, in which an egg is fertilized by multiple sperm, can result in a mosaic of diploid female and haploid male tissues. Finally, chromosome elimination – a hypothesis supported by the modern understanding of the sex determination system (sl-CSD) – explains gynandromorphism as the loss of a sex chromosome during the first cell divisions, producing an individual with genetically distinct sexual tissues (Michez et al., 2012). In addition to genetic causes, other causal mechanisms inducing gynandromorphism in Hymenoptera have been studied. Cold shock of honey bee eggs, for example (e.g., Drescher & Rothenbuhler, 1963), can produce gynandromorphs via delayed fertilization – where the egg nucleus begins division before sperm fusion, forming haploid (male) tissues alongside diploid (female) tissues – and via polyspermy, where multiple sperm fertilize the same egg, producing parallel haploid and diploid cell lines. Both processes generate mosaic individuals. Manipulation of the endosymbiont *Wolbachia* is another potential mechanism (Narita et al., 2010; Tulgetsk, 2010). Normally, *Wolbachia* converts unfertilized eggs into diploid females, but exposure of infected females to high temperatures can partially suppress this effect, leading to incomplete diploidization and resulting in a mosaic of haploid (male) and diploid (female) cells. The exact mechanisms underlying gynandromorphism in Hymenoptera are still not fully understood.

### Acknowledgements

We are grateful to Miguel Kurz for the specimen collection. This work was supported by CNPq productivity grant for RBG (process 307671/2021-6).

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